Pleistocene Island Occupation in the Mediterranean: Insights from a Tied-Biome Approach to Glacial Refugia

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Cover image: An archway within Gasr ash-Shahdiyn, a Late Roman fortress located on the main road between Al-Baida and Al-Maj, 4.5 km southwest of the Wadi Kuf bridge, Libya. (Photograph: Ryan Rabett, 2008; details: Paul Bennett).

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Chapter 6

Pleistocene Island Occupation in the Mediterranean: Insights from a Tied-Biome Approach to Glacial Refugia

Nellie Phoca-Cosmetatou and Ryan J. Rabett

Introduction: islands in human evolution

Concepts drawn from 'island biogeography' (MacArthur & Wilson 1967; Whittaker & Fernández-Palacios 2007), such as size, configuration and distance to other landmasses, have been, and continue to be, closely bound up within the growing sub-field of Island Archaeology. The idea that islands can provide laboratories for studying concepts of cultural change (e.g. Clark & Terrell 1978; Evans 1973) akin to the way they were proposed within biogeography to elucidate 'ideas about the structure of plant and animal communities' (May 1975, 177) has been largely superseded (for different discussions, see Broodbank 2006; Rainbird 2007); however, the crucible of an insular situation continues to exert authority in studies of early humanity, wherein islands are often viewed as an ideal setting to explore the dynamics of hominin adaptation: epitomizing both the refugial setting and the isolation that has driven behavioural and physical change (e.g. Erlandson 2010; Heinrich 2004; Morwood & Jungers 2009). The ability to cross the sea (to breach the barrier between habitat patches) carries profound conceptual as well as real-world significance for early colonizers, to the extent that maritime activities have come to be seen as a mark of emerging human behavioural complexity (e.g. Davidson 2010; Davidson & Noble 1992; O'Connell *et al*. 2010). The ability to access and move between island settings has also become the subject of considerable attention because of the economic and demographic expansion it permits (Anderson *et al*. 2010; Broodbank 2006; 2013).

Nonetheless, pre-*sapiens'* seafaring abilities continue to be widely questioned. Morwood & Jungers (2009) concluded that colonizing Flores was always a challenging prospect, one that few land mammals had achieved over the last 900,000 years. The arrival of the hominins responsible for making the Wolo Sege (Brumm *et al*. 2010) artefacts and (possibly separately) the arrival of *Homo floresiensis* are thought most likely the outcome of rare accidental events (for discussion, see Rabett 2012). Erlandson (2010) pointed out that the implication of Greater Australia only being colonized by anatomically modern humans was that earlier hominin species were not capable of large-scale, purposeful oceanic crossings. Broodbank (2006) suggested that the separate evolutionary trajectories between Neanderthals in Europe and *Homo sapiens* in Africa are an indication that the Mediterranean was not crossable. Despite these misgivings, the 'distinctly human' nature of maritime practice is being eroded by accruing evidence of both marine exploitation and freshwater crossings evident from sites attributed to pre-*sapiens* (Alperson-Afil *et al*. 2009; Braun *et al.* 2010; Colonese *et al*. 2009; Joordens *et al*. 2009); as well as by questions that continue to be raised when Palaeolithic stone tools and fossils are discovered on remote islands (Dennell *et al*. 2014; Mijares *et al*. 2010; Strasser *et al*. 2011).

Although the Mediterranean is one of the most archaeologically studied areas of the world, the first appearance of humans on islands here seems to have taken place much later than in areas far less heavily studied, such as the Pleistocene islands of Southeast Asia and Sahul (Piper & Rabett 2014). In his recent overviews of human maritime activity across the Mediterranean, Broodbank (2006; 2013) concluded that there is little secure, albeit tantalizing, evidence for early human ventures off the continental landmasses until *c*. 12,000 years ago (see also Simmons 2012) ; he considers any possible earlier maritime activity as having been episodic, refugia-driven and of (potentially) limited evolutionary significance (Broodbank 2006, 207; 2013, 95–6). Mesolithic seafaring is now quite firmly established, based on recent finds from Crete, the Aegean, Sardinia and Corsica (Depalmas 2013; Sampson 2008a,b; Sampson *et al*. 2012; Strasser *et al*. 2010). Full-fledged maritime cultures emerge only with the Neolithic and farmers (Dawson 2011; Phoca-Cosmetatou 2011a).

Intriguing, from our perspective, are the sites dating to the Late Glacial (14,600–11,700 cal. BP): Ouriakos on Limnos (Efstratiou *et al*. 2013) and possibly Aspros, Nissi and Aetokremnos on Cyprus (Ammerman 2010; Simmons 2011), as well as the presence of obsidian from Melos at the mainland site of Franchthi (Perlès 1999). Their occurrence within the Younger Dryas (12,800–11,700 cal. BP) led Ammerman (2010) and Broodbank (2013) to argue for a causal link between this maritime activity and the Natufian population expansion in the Levant – with the increased resource pressure this brought. There is slightly earlier evidence from Sicily, from *c*. 16,700 cal. BP (Grotta dell'Acqua Fitusa: Mussi 2007), which spans the Late Glacial (D'Amore *et al*. 2009; Mannino *et al*. 2011; 2012); Sicily, though, was very close or joined to mainland Italy. These forays appear to have been quite localized and fall short of full-fledged, purposeful seafaring, though they were moving in that direction.

The level of uncertainty increases for the millennia during and before the peak of the Last Glacial Maximum (LGM, 21,000±2000 years ago: after Mix *et al*. 2001). Nonetheless, almost all major Mediterranean archipelagos – bar the Balearics – have produced finds that their discoverers claim indicate such a presence: including Cyprus, Crete (and Gavdos), Melos, Alonnisos and other islands in the Sporades, Cephallonia, Sicily, Malta, Sardinia and Corsica. At the same time, almost all of these finds are considered, to a greater or lesser extent, contentious, raising the possibility that early forays might not have taken place at all. Two indirect lines of evidence, namely sea crossings and marine-resource exploitation, can be used to provide further insights about the extent and nature of Palaeolithic island visits.

Pleistocene sea crossings have focused primarily on the Strait of Sicily and Straits of Gibraltar. The distance between Tunisia and southwest Sicily would have been *c*. 45–60 km at LGM sea levels (Furlani *et al*. 2013; Shackleton *et al*. 1984), though not without potential island stepping-stones. The insularity of Sicily itself continues to be debated (see below). Lower sea levels during the last glaciation would also have exposed islands within the Straits of Gibraltar and reduced the distance (currently 14 km) to short stretches of *c*. 5 km (Collina-Girard 2001; Straus 2001). Glacial constriction of the straits, though, would have strengthened subsurface currents flowing into the Mediterranean basin (Mikolajewicz 2011; Voelker *et al*. 2006), accentuating the difficulty of a crossing. From an archaeological perspective, the evidence is slim (Garcea 2004; 2012; Straus 2001): on the Spanish side, deep-sea fishing starts to appear from the Late Glacial (e.g. Morales *et al*. 1998); on the Moroccan, this same period sees the enigmatic presence of a single harpoon from Taforalt Cave (Straus 2001) and the hint of possible contact with Europe on typological grounds. Most faunal studies also conclude that the straits constituted a barrier, with palaeontological studies supporting a Pyrenean route into Iberia (e.g. O'Regan 2008) and a west Asian route for mammals into Eurasia (Lahr 2010) in the Lower Pleistocene. Against this, occasional findings do offer glimpses of a different scenario. For example, a mtDNA study of human populations from Morocco and Spain found genetic structure suggestive of a post-LGM expansion across the straits (Rhouda *et al*. 2009). Also the phylogeographic structure of the greater white-toothed shrew (*Crocidura russula*) on either side of the straits suggests transferral from Morocco to Europe 50,000–80,000 years ago, leading the authors to posit the chance that this could have been aided by human maritime crossings (Cosson *et al*. 2005).

A second, less direct, proxy for maritime activities comes from marine-resource exploitation, including from molluscan, fish and isotope studies. Mollusc exploitation has been recorded across the Mediterranean during the Middle Palaeolithic. Around 20 Neanderthal sites have yielded marine mollusc remains, mainly in southern Iberia and west-central Italy, with the earliest claim from Bajondillo Cave, southern Spain (160,000 years ago: Cortés-Sánchez *et al*. 2011) – notwithstanding the Lower Palaeolithic finds at Terra Amata and Lazaret (both in southern France) of uncertain taphonomic provenance (Colonese *et al*. 2011). *Homo sapiens* sites containing such evidence appear in the Levant and North Africa, with perforated specimens coming from Es-Skhūl, Israel (135–100,000 BP), Oued Djebbana, Algeria (90–35,000 BP) and Taforalt, Morocco (*c*. 82,000 BP) (Bouzouggar *et al*. 2007; Vanhaeren *et al*. 2006). Burnt fragments of *Osilinus turbinatus* of probable MIS 5 antiquity at the Haua Fteah, Libya (Barker *et al*. 2010; 2012) are notable, as are edible species from deposits at Üçağızlı II (Turkey) (Stiner 2009) – though the species of hominin responsible is not known for certain in either case. The nature and frequency of mollusc exploitation remains at comparable levels during the early Upper Palaeolithic (e.g. Riparo Mochi, Italy; Üçağızlı I; Cueva de Nerja, Spain); there is no sudden jump until after the LGM, when the exploitation of molluscs increases in both frequency and intensity (Colonese *et al*. 2011).

Fish represent an elusive category of food remains. Compared with South Africa (Erlandson 2001) they appear only rarely from sites along the Mediterranean coast of the continent (e.g. Barker *et al*. 2012), and are found infrequently at Middle Palaeolithic sites (Steele & Álvarez-Fernández 2011) – though trans-Saharan human dispersal is considered to have

been closely linked to the exploitation of aquatic fauna (Drake *et al*. 2011). According to Stiner (2005), fishing increased in importance only after 20,000 years ago, when marine species first make their appearance (Morales-Muñiz & Roselló-Izquierdo 2008); though see Bicho and Haws (2008). Álvarez-Fernández (2011) stated that for Cantabrian Spain, although bones of the anadromous salmon are found at Middle Palaeolithic sites, the first evidence for exclusively marine fish does not appear until the Late Glacial during the middle Magdalenian. Taphonomic issues affect the certain identification of fishing (Erlandson & Moss 2001; Fiore *et al*. 2004). Even the presence of pelagic fish remains cannot be taken at face value as *bona fide* evidence of deep-sea fishing capabilities (Anderson 2013). Isotopic studies concur that fish, including marine, did appear in people's diet in Europe from the early Upper Palaeolithic onwards (Richards & Trinkaus 2009), but not among Neanderthals (Bocherens 2011). However, isotopic signatures only highlight those food sources that were often consumed; other taphonomic constraints aside (e.g. introduction of remains by fish-eating raptors), the recovery of occasional marine fish finds still suggests periodic exploitation.

Marine mammals represent a third line of evidence for the exploitation of marine resources. Seals and dolphin bones have been recovered from Mediterranean sites, albeit in low numbers: examples include the Middle Palaeolithic sites of Vanguard and Gorham's caves, Gibraltar (Stringer *et al*. 2008); Sant'Agostino, Italy (Stiner 1994); the Middle Stone Age site of Mugharet el 'Aliya (Morocco) (Steele & Álvarez-Fernández 2011); as well as during the Upper Palaeolithic, e.g. at Arene Candide, from Early Epigravettian levels (Cassoli & Tagliacozzo 1994). Frequent exploitation, though, seems again to arrive only during the Late Glacial (e.g. Álvarez-Fernández 2011; Aura *et al*. 2009). The presence of cut-marks on seal bones strongly reinforces the likelihood of hominin exploitation, e.g. as at Gorham's Cave and Sant'Agostino. Dolphins (Aguilar & Raga 1993), though, could have been scavenged from the strandline, while the once ubiquitous monk seal (*Monachus monachus*) could have been encountered on open beaches (Johnson & Lavigne 1999).

In sum, the evidence for sea crossings and marine exploitation paint a picture that parallels the current island evidence: a contrast between pre- and post-LGM human behaviour. Even so, there remain sufficient hints that perhaps opportunistic marine resource exploitation did feature in some fashion in pre-LGM subsistence strategies. This, together with mounting evidence for plant food use by Neanderthals (e.g. Brown *et al*. 2011; Henry *et al*. 2010; Lev *et al*. 2005) and early modern human groups (e.g. Weiss *et al*. 2004), highlights the significance of recovery bias and seemingly the importance of diet breadth to Mediterranean populations compared with their more systematically studied north European neighbours (Stiner 2001; 2005).

The acquisition of marine resources, though, does not imply seafaring; at best it provides a context for the development of seafaring. This leaves direct evidence of island occupation itself as potentially our most direct route to uncovering pre-LGM maritime activity. Island Archaeology in the Mediterranean has tended to suffer from the tyranny of the Neolithic, as the period of the first permanent island occupation (Dawson 2011; Phoca-Cosmetatou 2011a). Only in recent years have researchers become increasingly open to the idea of a pre-Neolithic and even pre-*sapiens* presence on Mediterranean islands, a shift that perhaps partially owes its motivation to island discoveries made half a world away in Southeast Asia. Alongside, if not in consequence of, this interest have been calls for the adoption of new research approaches explicitly geared towards the robust and ideally *in situ* recovery of Mesolithic and Palaeolithic material (Ammerman 2010; Panagopoulou *et al*. 2001; Strasser *et al*. 2010; 2011). The unambiguous evidence for human presence on Mediterranean islands still dates to no more than *c*. 16,000 years ago, but the voices across the water from the Pleistocene are getting louder.

In this chapter we consider closely the variables affecting the preservation and recovery of Pleistocene island records in the Mediterranean, before approaching the matter of Palaeolithic island occupation from a new perspective. If permanent settlement and trading networks typify island interaction in the Neolithic (Dawson 2011; Phoca-Cosmetatou 2011a) and purposeful seafaring and 'foraging seascapes' (Barker 2005) typify Mesolithic island use, what were the dynamics of that relationship before the LGM? If new approaches to surveying the land are paying dividends in terms of site recovery, what further reward may lie in linking Pleistocene islands to their glacial seas? We argue that the incorporation of marine with terrestrial biodiversity 'hotspots' from across the Mediterranean into an archaeological model permits two contentions relevant to Pleistocene island use.

Firstly, and following the logic and findings of Médail and Diadema (2009) linking terrestrial biodiversity hotspots and glacial refugia around the Mediterranean (Fig. 6.1), we contend that marine biodiversity hotspots are likely to be associated with marine refugia. Secondly, an observed association between Palaeolithic sites and terrestrial refugial enclaves leads us to hypothesize that there would be an enhanced likelihood of occupation evidence in those areas where

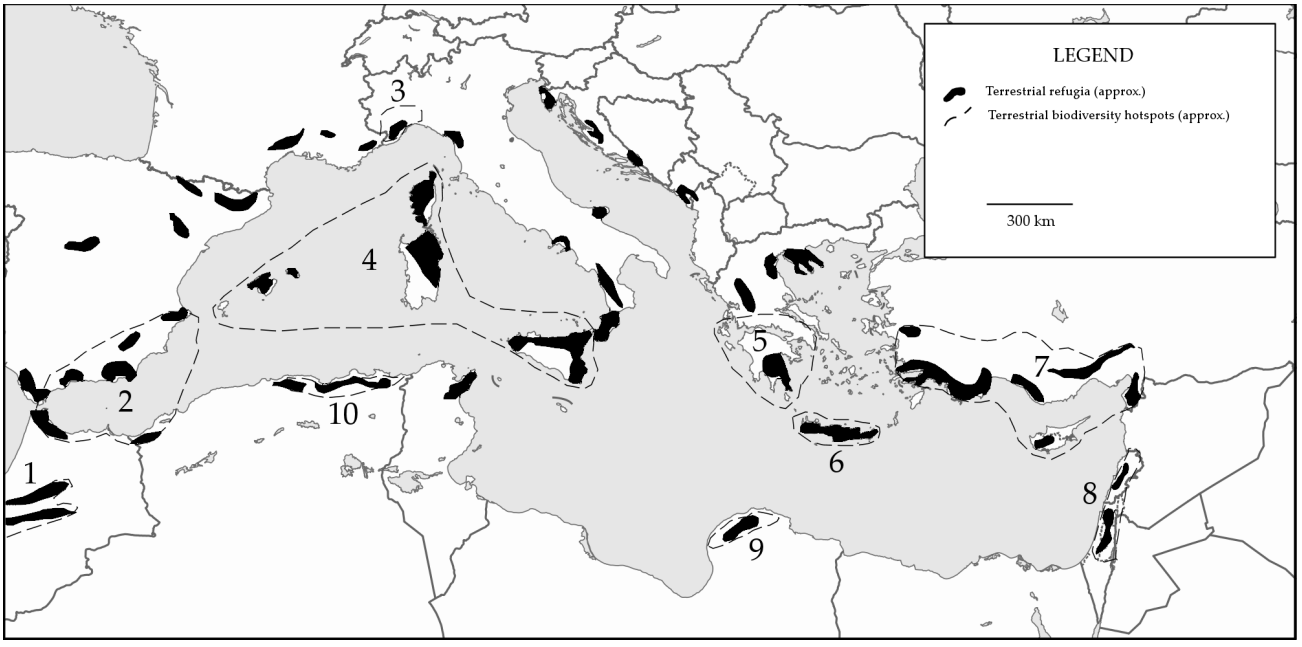

Figure 6.1. *Locations of 48 of the 52 glacial terrestrial refugia and 10 biodiversity hotspots identified by Médail and Diadema (2009) (redrawn) – those not included lie outside the view of the current map. (Illustration: R. Rabett.)*

terrestrial and marine zones of biodiversity overlap. We propose that under this 'tied-biome' scenario certain islands and archipelagos become incorporated within a wider geographic zone: one that encompasses land and sea within a species-rich and resource-stable environment, factors attractive to promoting early human dispersal and island occupation. We use the term 'occupation' here to indicate human presence on a particular island without making any inference about the permanence of that stay, and to distinguish Palaeolithic maritime activities from more formalized colonization processes in later prehistory (Dawson 2008). We suggest this offers a better way to understand the early human evidence that has thus far been discovered, and to begin building a robust predictive model to guide us towards future discoveries, instead of back-projecting Neolithic (or even Mesolithic) models of more formal island exploitation and permanent settlement into the Pleistocene.

Taphonomic issues surrounding Pleistocene island occupation in the Mediterranean

Of the thousands of islands that dot the Mediterranean, 145 currently have evidence of prehistoric human occupation (Dawson 2011). Due to fluctuating sea levels, many present-day islands were attached to the mainland during periods of lower sea level. Our study will concentrate only on those islands that were separated from the mainland even during the LGM – when sea levels dropped to their lowest point (–125 m). The great uncertainty that has surrounded past claims for the occupation of Mediterranean islands, and especially those prior to the LGM, stems from their failure to meet one or both of two widely used criteria (Price 1977, 69): namely, an undisputable Pleistocene-age context, either based on geological analysis or chronometric date; and the presence of diagnostic stone tools that are *clearly* characteristic of a Palaeolithic industry known from the mainland. Claims for finds of Pleistocene antiquity tend to fall into three main categories:

1. Lithic artefacts. Most reports are of surface scatters without any stratigraphic or chronological context. Lithics tend to comprise isolated finds in secondary deposits, and often lack diagnostic typological or technological features;
2. Human bones. Reports of human remains are often unable to provide robust provenance, associations to cultural material or reliable chronometric antiquity;
3. Indirect evidence. This mainly appears as 'features' interpreted as being potentially of anthropogenic origin; or from palaeontological sites with no associated hominin fossil or cultural material, but where evidence of substantial faunal turnover is attributed to the arrival of and subsequent predation by hominins.

Rarely has there been any systematic excavation of purportedly early sites and we are still over-reliant on inadequate hints and possibilities about early maritime activities. There are a number of possible reasons for this situation. Island visits, if they occurred at all, may have been infrequent, ephemeral affairs, resulting in very low archaeological visibility. Add to this the multiple variables affecting preservation and a research and survey agenda in the Mediterranean that has not been geared towards looking for Palaeolithic material in the first place, and we are left to wonder exactly what the existing patterns of recovery are actually telling us.

If we accept the plausibility that pre-LGM humans visited at least some Mediterranean islands, we must start by considering the taphonomic processes that could distort what few remains they might have left behind. The main geological factor is, without question, the effect of changes in sea level between the Pleistocene and the Holocene. During the last 150,000 years, allowing for several regression and transgression phases, sea levels were, on average, 40 m lower than at present (Bailey & Flemming 2008). As a result, large tracts of land, some almost certainly available for human occupation, were exposed for long periods of time. The onset of deglaciation after the LGM *c*. 19,000 years ago heralded a substantial rise in global sea levels, including punctuated episodes of rapid inundation (e.g. Fairbanks 1989; Lambeck *et al*. 2002). With the submergence of continental margins and low-lying insular plains, such as the Cycladic Plateau, across the Mediterranean a substantial portion of any coastal occupation was removed from the terrestrial site register. The net result is that evidence of marine resource exploitation will only be visible archaeologically from those locales where there has been tectonic uplift and/or from raised beaches left from inter-glacial high-stands (Bailey 2010) – with some of these, such as the MIS 5e high-stand, having potentially washed out older sites from lower elevations (Stiner 2010). Thus, the discovery of island occupation dating to the Late Glacial and thereafter might itself be an artefact related to the latter-day stabilization of sea levels and, therefore, increased visibility (Knapp 2013; Stewart & Morhange 2009). Areas of steep coastal relief and tectonic uplift might better preserve palaeo-shorelines, though Bailey and Flemming (2008) have questioned this.

Calculating past sea levels is complicated by the fact that, in addition to local topography and bathymetry, eustatic change is affected by a range of other geological processes. Tectonic displacement in the Aegean, for example, led to sea levels during the LGM actually varying between –115 and –130 m, compared with the eustatic value of –125 (Lambeck 1996); between the Golfe du Lion and the Côte d'Azur during the LGM, levels varied from –105 to –115 m (Lambeck & Bard 2000). Tectonic movements, in particular, provide a substantial off-set that must be taken into account wherever possible – a primary cause of the uncertainty surrounding the status of Sicily as an island during the Pleistocene. In the Aegean, displacements range from 0.9 to 21 m (Perissoratis & Conispoliatis 2003). In the Gulf of Corinth, the MIS 5e shoreline is uplifted by 150 m (Armijo *et al*. 1996). In addition to uplift and subsidence, fluvial and coastal erosion processes must also be accounted for. Holocene deposition processes (alleviation and colluviation) can bury sites under thick sediments and can themselves contribute to masking absolute changes in sea level (Correggiari *et al*. 2001; Perissoratis & Conispoliatis 2003).

The nature of the Palaeolithic record on Mediterranean islands is also partly structured by the history and preconceptions of archaeological research there. The accumulation of claims for an early human presence on islands, made since the early twentieth century, have been subjected to rigorous critique in recent decades (e.g. Cherry 1981; 1990; Ammerman & Noller 2005 cf. Simmons & Mandel 2007) resulting in a 'loss of innocence' for Island Archaeology. The fact that many finds were made by non-Palaeolithic archaeologists, without the support of geological experts, has compounded the problem. The absence of full publication of purported finds and the difficulties involved for specialists in tracking down and studying the material have meant it has often been impossible to provide a well-founded assessment. As a result, reconsideration of evidence must often conclude with uncertainty. Occasionally, though, the baby does appear to have been thrown out with the bathwater, as claims of early island occupation have been subjected to a level of scrutiny probably greater than that for equivalent finds on the mainland. The Mesolithic site of Maroulas, Kythnos, provides an example. Cherry (1981) had dismissed as unsubstantiated early assertions for Mesolithic occupation and burials, only to be found wrong when a full excavation of Maroulas was commissioned and new radiocarbon dates corroborated the old ones (Sampson 2008b).

The tide does now seem to be turning, with greater willingness to accept the ability of Palaeolithic groups to reach island settings, leading to four important theoretical developments. Firstly, there is renewed interest to explore the origins of seafaring and of maritime activities (e.g. Anderson *et al*. 2010; Broodbank 2006) and the maritime capabilities of early humans are increasingly accepted – or being

seriously discussed. Secondly, we no longer view smaller islands as necessarily unsuitable habitats for hunter-gatherers (Phoca-Cosmetatou 2011b). Thirdly, the study of early island occupation is increasingly coming under the direction of Palaeolithic archaeologists, geologists and geomorphologists specializing in Quaternary studies (e.g. Panagopoulou *et al*. 2001; Strasser *et al*. 2010). Finally, recent initiatives have started to employ predictive models specifically tailored for identifying pre-Neolithic sites. Given that the majority of archaeological surveys in the Mediterranean have been large in scale, diachronic and concerned with developments in later periods, neither survey design nor the significance of Palaeolithic finds has been a driving consideration. The differences in settlement systems and resource exploitation that exist between permanent communities of villagers and mobile hunter-gatherers mean that locales preferred by the former were not necessarily shared by the latter. Recent attempts to target the earliest evidence of island use, by contrast, focus on particular regions that fit the requirements of predictive site-location models. These might be, for example, concentrated on the past distribution of resources tailored to the recovery of Mesolithic locales: namely, the interface between terrestrial and aquatic habitats in areas rich in small caves and rock-shelters and in close proximity to freshwater wetlands along the coastal zones (Runnels *et al*. 2005). When this model was applied to southern Crete (Strasser *et al*. 2010), data on Mesolithic and Palaeolithic occupation started to flow in. The approach adopted by Ammerman (2010) focussed on carrying out fieldwork during different times of the year (winter for greater site visibility) and on different landforms (aeolianites), which had been avoided in past surveys because they were considered to be too marginal; choices that appear to have borne fruit with Ammerman's discovery of Late Glacial sites at Nissi and Aspros on Cyprus.

A feature common to both the above expeditions was that the localities they discovered yielded remains of Mesolithic and late Upper Palaeolithic occupation, but little evidence from later periods. This served as a demonstration that early hunter-gatherer land-use practices exhibited their own unique character that was not only different from later, more settled communities, but which was also under-represented when recovery strategy focused on the Neolithic and later periods. This finding echoes biogeographic thinking: the autecological response of species means that the insularity of the same piece of land will mean different things to different species (Haila 1990). As we wind back the clock, a similar distinction may also be expected to exist between post- and pre-LGM site locations. Although Strasser *et al*. (2010) claim the discovery of Lower/Middle Palaeolithic stone tools, their site-location model was developed in relation to expectations of Mesolithic island use. To date there has not been a predictive model tailored to the glacial period of the Pleistocene. Just as new and targeted research has uncovered a pre-Neolithic presence on islands, it seems likely that, in the future, allowing for taphonomic constraints, the antiquity of island use may be pushed back further if sympathetic models are used. This chapter takes one step towards identifying one such model.

Terrestrial–marine biodiversity and Pleistocene island occupation

Under the fluctuating climatic conditions of the Pleistocene, the three principal southern European peninsulas of Iberia, Italy and the Balkans have featured strongly as providing refugial environments (e.g. Hewitt 1999; 2000; Taberlet *et al*. 1998). These represent geographic areas of relative ecological stability, affording suitable habitats for the long-term (ideally through glacial-interglacial cycles) persistence and survival of populations more or less in the same place (Tribsch & Schönswetter 2003; Tzedakis *et al.* 2013). The importance of refugia in human evolution, geographical range and speciation is increasingly recognized (e.g. Bailey *et al*. 2008; Barker *et al*. 2009; Basell 2008; Carrión *et al*. 2011; Gamble *et al*. 2004; Stewart & Stringer 2012; Tourloukis & Karkanas 2012). In the Mediterranean, the late persistence of Neanderthals across southern Europe has been correlated to suitable refugial conditions (e.g. Delson & Harvati 2006; Finlayson 2008). During the LGM, repetitive occupation and dense site distribution have also been found to coincide with the geographical distribution of glacial plant refugia in the Adriatic region (Phoca-Cosmetatou & Spry-Marqués, forthcoming) and during the Middle and Upper Palaeolithic across Iberia (Bradtmöller *et al*. 2012; Schmidt *et al*. 2013).

The palaeobotanical record suggests that refugia constituted restricted geographical areas scattered across multiple regions (Magri 2008). Fifty-two putative plant refugia, associated with ten biodiversity hotspots, have been identified across the Mediterranean (Fig. 6.1; Médail & Diadema 2009). Although the spatial delimitation of refugial locales has proven a challenge, these authors identified a range of different types, including mid-altitude areas, deep gorges and valley bottoms, which would also have differed in size. Many refugia are located close to the present-day coastlines, and with lower sea levels during the LGM these restricted geographical areas could have

been more extensive. Animal refugia, also identified across the three peninsulas of southern Europe, tend to be broader in their geographical delimitation (Hewitt 2000; Sommer & Zachos 2009). No geographical delimitation of marine refugia has yet been attempted – although their existence is mooted through phylogeographic studies (see below) – and the concept of tied refugia has only begun to be explored on land (e.g. García-Barros *et al*. 2002).

We base our model on the simple principle that the long-term persistence of refuge habitats in the Mediterranean is tied to the geographic relationship *between* land and sea. For example, the maintenance of the terrestrial refugium in the Ioannina basin of western Greece is strongly predicated by the orographic uplift of moisture-charged air from the waters of the Ionian Sea under both modern and glacial conditions (Tzedakis *et al*. 2002). Conversely, the rich biodiversity of cold-temperate marine species in the Ligurian Sea and Golfe du Lion relies on the continued presence of cold mistral winds funnelling down the Rhône and Garonne Valleys (Astraldi *et al*. 1995). We develop this relationship with reference to spatial studies compiled recently for modern marine biodiversity and endemism across the Mediterranean (e.g. Boudouresque 2004; Coll *et al*. 2010; 2012). The primary concern of these reports is future conservation rather than past evolutionary change. Nonetheless, they provide valuable evidence germane to our proposed model.

In order to identify areas of the Mediterranean that are likely to have hosted marine refugia, we build on two conclusions that have been reached through land-based studies: firstly, the established link between terrestrial species endemism and glacial refugia (e.g. López-Pujol *et al*. 2011; Schönswetter *et al*. 2005; Tribsch & Schönswetter 2003); secondly, the degree of concordance that exists between phylogeographic-based plant refugia and biodiversity 'hotspots' (*sensu* Myers 1988; 1990) – namely, areas of high species richness and pronounced endemism that are also under threat of destruction (Médail & Diadema 2009; Tzedakis 2009). The reasoning we employ is as follows: if we can identify marine biodiversity hotspots, these locales are more likely to be associated with marine refugia than other areas of the Mediterranean.

Overall, present marine biodiversity of the Mediterranean is strongly influenced by its relationship to the Atlantic, from which it is said to have received a 'diversity pump' from the Pliocene onwards (Bianchi & Morri 2000). As a result of this, the sea's own complex geological history and the impact of changing environmental conditions, the Mediterranean contains species belonging to several different biogeographic categories: temperate species, panoceanic species, endemics (palaeoendemic species (of possibly Tethyan origin) and neoendemics mainly of post-Pliocene origin), sub-tropical Atlantic species (thought to be interglacial remnants), boreal Atlantic species (considered to be glacial remnants), Atlantic migrants (particularly in Alboran Sea) and, since the opening of the Suez Canal in 1869, also what are called 'Lessepsian' migrants from the Red Sea.

Allowing for the fact that far less biological research has taken place in the east than in the west Mediterranean (Clusa *et al*. 2013; Gaetner *et al*. 2007), modern marine fish biodiversity appears most pronounced in the coastal waters of the western basin compared with the eastern – as delimited by the Strait of Sicily (Coll *et al*. 2010; 2012). The Adriatic and western coastal waters of Greece show only slightly lower levels of biodiversity; the Aegean, Turkish, Levantine and North African coasts (with the exception of the gulfs of Hammamet and Gabès, off the coast of Tunisia) are less diverse again. By contrast, evidence of marine fish endemism favours higher trends in the eastern Mediterranean (Coll *et al*. 2010) and, as with marine species richness, there is a pronounced drop-off in numbers away from coastal waters.

Phylogeographic studies into marine fish species show repeatedly that genetic distinctiveness exists between western and eastern populations, with further population sub-divisions appearing in the eastern Mediterranean. Examples of such studies include the eastern sea bass (*Dicentrarchus labrax*: Bahri-Sfar *et al*. 2000), bluefin tuna (*Thunnus thynnus thynnus*: Carlsson *et al*. 2004), parrot fish (*Sparisoma cretense*) and wrasse (*Thalassoma pavo*: Domingues *et al*. 2008), the European anchovy (*Engraulis encrasicolus*: Magoulas *et al*. 2006), as well as the swordfish (*Xifias gladius*: Viñas *et al*. 2010). The greater genetic diversity exhibited in the eastern basin is attributed to the likelihood that this part of the Mediterranean hosted the greater proportion of marine refugia during the last glacial period due to warmer and more stable sea surface temperatures (SSTs) (see Hayes *et al*. 2005; Thiede 1978). This conclusion is independently supported by the phylogeography of marine animals. For example, new genetic evidence presented by Clusa *et al*. (2013) for the loggerhead turtle (*Caretta caretta*) has challenged prevailing wisdom that this marine reptile only entered the Mediterranean within the last 12,000 years (Bowen *et al*. 1993). Drawing on the highly philopatric behaviour of the species and the mtDNA structuring this creates, Libya, western Greece and eastern Turkey have been identified as the three locales of highest genetic diversity and deepest antiquity for the loggerhead turtle – with each pre-dating the LGM.

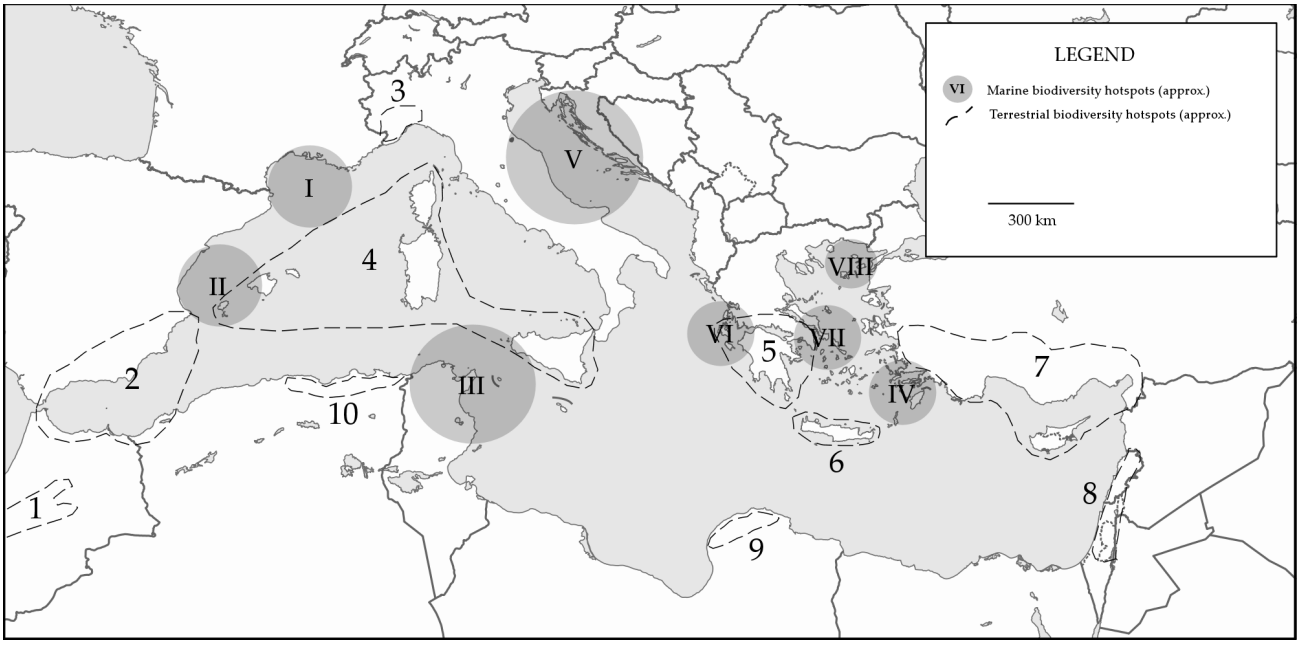

Figure 6.2. *Comparison of putative marine fish biodiversity hotspots with reported terrestrial (plant) hotspots. (1) High and Middle Atlas; (2) Baetic-Rifan complex; (3) Maritime and Ligurian Alps; (4) Tyrrhenian Islands; (5) south and central Greece; (6) Crete; (7) south Anatolia and Cyprus; (8) Syria–Lebanon–Israel; (9) Cyrenaica; (10) Kablies–Numidie–Kroumirie (after Médail & Diadema 2009); (I) Golfe du Lion; (II) Balearic Sea; (III) Gulf of Tunis to the Gulf of Hammamet; (IV) southeast Aegean; (V) Adriatic; (VI) south Ionian islands; (VII) western Aegean (off Euboea and Attica); (VIII) northeast Aegean (based on Coll* et al. *2010; 2012). (Illustration: R. Rabett.)*

The proposed Late Pleistocene antiquity (*c*. 30,000 years) of *Caretta caretta* nesting grounds in western Greece (see Margaritoulis 2000), as well as probably older rookeries along the coasts of Libya and eastern Turkey, have been taken as evidence that these may have represented refugial areas during the last glaciations (Clusa *et al*. 2013).

Combined data on biodiversity and threat levels for several taxonomic groups of marine fauna from across the Mediterranean are presented in Coll *et al*. (2012). They employ an overlap index (OI) to express the degree to which these two variables intersect for different taxa, from a <25 per cent overlap (OI_{25}) to ≥75 per cent (OI_{75}). Reading these data in combination with those for fish endemism – i.e. in accordance with Myers' (1988) definition of a biodiversity hotspot – indicates the following with respect to the possible location of marine refugia (Fig. 6.2).

Species richness (cumulative data from 1980s–2000s) for fish is highest (nos. species or NTAXA: 340–375) in the waters off the Iberian and Tyrrhenian coasts, and in the central waters of the Golfe du Lion. Rates of endemism reach their highest (NTAXA: 37–45) only in the last of these areas, though, with marginally lower rates for the coastal waters of the Tyrrhenian and Ligurian seas, the Côte d'Azur and points around the Balearic rim (i.e. NTAXA: 29–36) and mid-range values along the remainder of the Iberian coast (NTAXA: 20–28). Points along all of these coasts have an OI_{50} value. From this, we might presume that a refugial area may exist in the general vicinity of the Golfe du Lion (I) and the Balearics (II). The coastal waters from the Gulf of Tunis east to the Gulf of Hammamet (III) and the southeast Aegean, off the Turkish coast (IV), have a comparatively high level of species richness (NTAXA: 253–339) and a high diversity-threat index ($OI_{50–75}$) (particularly focussed off the Tunisian coast), with mid-range rates of endemism (NTAXA: 20–28). Finally, the north and central Adriatic (V), Ionian coast (VI), the western Aegean – off Euboea and Attica (VII) – and the northeast Aegean (VIII) exhibit slightly lower species richness (NTAXA: 237–315), but a comparatively high level of endemism (NTAXA: 29–45) (especially along the Balkan coast of the Adriatic where endemism reaches NTAXA: 37–45) and a second level diversity-threat index of OI_{50}. Each of these areas may have been associated with marine fish refugia. More detailed calculations are needed to rank these candidates properly; here, we seek simply to highlight their presence.

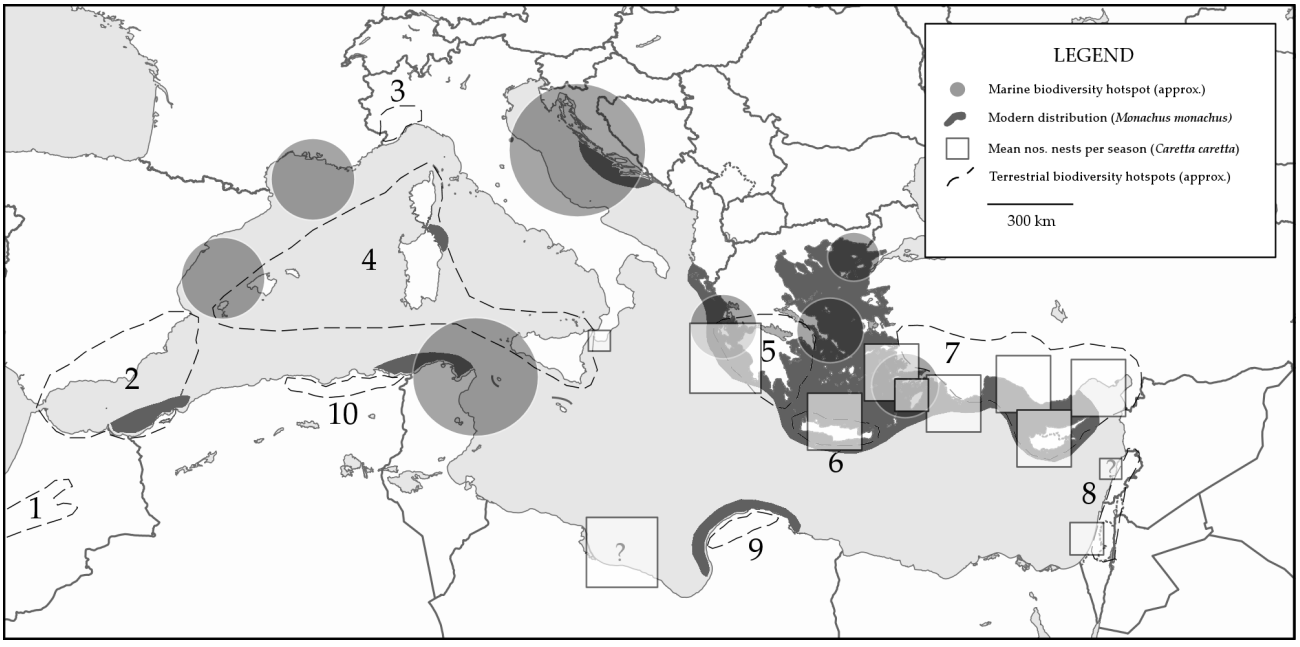

Figure 6.3. *Current distribution of the loggerhead turtle (*Caretta caretta*) (white squares) and Mediterranean monk seal (*Monachus monachus*) (shaded grey). Square size equates with average number of nests per season: >1000, 101–1000, 21–100 and 1–20 (largest to smallest); the question marks for Libya and Lebanon are estimated number of nests; the most ancient lineages appear from Libya, western Greece and eastern Turkey (Clusa* et al. *2013). Monk seal data after Masseti (2012). Note the broad correlation with known terrestrial (plant) hotspots of biodiversity in all cases except Libya, and the possible ties to selected marine (fish) biodiversity hotspots (grey circles) from Figure 6.2. (Illustration: R. Rabett.)*

An important constraint affecting the general location of these putative glacial marine refugia is that all of the identified marine hotspots are in close association with continental shelves. These would have been at least partly emergent during the last glacial. How the drop in sea level and change in conditions would have altered the glacial distribution of biodiversity is a critical matter, but one which, unfortunately, is still not well understood (see Bianchi & Morri 2000; Patarnello *et al*. 2007). Occasionally, however, we do have glimpses of local responses to glacial cycles, as the example of sand smelt (*Atherina* sp.) shows (Congiu *et al*. 2002). The low genetic divergence between the Adriatic and Ionian populations of this fish possibly indicates that progressive reduction in the exposure of the Adriatic plain during deglaciation encouraged expansion of the sand smelt up from the Ionian Sea (Kraitsek *et al*. 2012). The tentative conclusion that we might draw is that at least some marine refugial locales probably endured the minima of the last glaciation in adjacent habitats, which are today deeper portions of the continental shelf.

To add an independent line of evidence in support of these predictions we have mapped the distribution pattern of loggerhead turtle and monk seal (*Monachus monachus*) populations (Fig. 6.3), both of which nest on land. Their current distribution coincides not only with certain marine biodiversity hotspots (as one might expect), but also strongly with terrestrial hotspots. The phylogeographic data for *Caretta caretta* were presented above; the only exception in the concordance data for this species appears to be the Libyan centre. This is removed eastwards from the Cyrenaican hotspot to the vicinity of Sirte; however, the geographic extent and significance of rookeries along this coast (including Cyrenaica) is still being determined (Saied *et al*. 2012).

The current distribution of the highly endangered *Monachus monachus* includes the Baetic-Rifan complex coastal area, the Gulf of Tunis, Cyrenaica, northern Sardinia, the central Balkan coast of the Adriatic, the Ionian coastline, the Aegean and southern Anatolian coasts (Masseti 2012; Panou *et al*. 1993). While this represents the current distribution pattern of monk seals, we note from studies examining recolonizing populations out of terrestrial refugia that such expanding groups are more liable to become extinct than to track a retreating habitat when climatic change

prompts refugial confinement (Hewitt 1999; Stewart *et al*. 2010). Following this reasoning, we suggest that although monk seal populations were once ubiquitous around Mediterranean coasts (Johnson & Lavigne 1999), much of that range may represent an extension out of cores of highest resilience (e.g. Pastor *et al*. 2007): namely, those areas that persist today despite human and other impact.

This preliminary assessment of hotspot concordance between terrestrial and marine biomes suggests that we might expect the south-central Greek terrestrial plant hotspot (5 & 6; Fig. 6.2) of Médail and Diadema (2009) to extend into the Ionian (VI) and west Aegean (VII) seas, as well as from land into the waters off southern Anatolia (7 and IV). On the North African coast, the Kabylies–Numidie–Kroumirie (10) botanic hotspot may be extended off the coast of Tunis (III) and may become incorporated into the eastern extreme of the terrestrial Tyrrhenian islands zone (4), as does that associated with the Balearic Sea (II). Only the potential marine biodiversity hotspots in the vicinity of Côte d'Azur–Golfe du Lion (I), the Adriatic (V) and northeast Aegean (VIII) do not appear to link immediately to a terrestrial partner. The Maritime and Ligurian Alps locale (3) identified by Médail and Diadema (2009) could qualify in the case of (I), but there is reason to query this.

The Golfe du Lion is one of the coldest parts of the Mediterranean today (Astraldi *et al*. 1995; Coll *et al*. 2010) and was equally so under glacial conditions (Hayes *et al*. 2005). In contrast to the terrestrial biodiversity hotspots and glacial refugia defined by Médail and Diadema (2009), which relate to thermophilous and mesophilous plant species, this area of the Mediterranean is marked by a bias towards cold-temperate species. This raises the possibility that it is related to an 'interglacial refugium' (see Bennett & Provan 2008) for mesophilous or even psychrotolerant marine biota. This does not preclude the importance of this environmental setting to early human groups – as we discuss below. What it does underscore is the point that glacial conditions will not necessarily have prompted the constriction of all habitat cores within a region.

Pleistocene island occupation: a tied-biome perspective

In this final section we examine the relevant archaeological evidence from each major island or archipelago in the Mediterranean. The credibility of each record is reviewed from the perspective and expectations of our tied-biome model. All are incorporated within wider terrestrial biodiversity hotspots. The largest insular landmasses of the Pleistocene Mediterranean – the islands of 'Corsardinia', Sicily, Crete and Cyprus – together with the Balearics are all known to have hosted terrestrial plant refugia (Fig. 6.1). None of these islands includes a hotspot for marine biodiversity, though Sicily and the Balearics are arguably the most closely linked to one. The Ionian and Aegean islands are notable in that they appear to fall within the sphere of marine biodiversity hotspots, as well as being linked to a terrestrial one. The Adriatic marine hotspot (V) did not include any islands during periods of low sea levels; with the possible exception of the tiny island of Palagruža (Forenbaher & Kaiser 2011), all other islands in this sea would have been incorporated into the exposed Great Adriatic Plain during the last glacial, and thus not considered further here.

Corsica and Sardinia

An Early Holocene Mesolithic presence on both Corsica and Sardinia is now firmly established (e.g. Depalmas 2013; Lugliè 2013). Under fully glacial conditions these islands would have formed a single landmass lying 7–15 km off the Italian coast (Shackleton *et al*. 1984). Claims for a post-LGM Upper Palaeolithic human presence are, unfortunately, highly questionable. Salotti *et al*. (2008) have argued for an anthropic origin to a bone accumulation at the A Teppa di U Lupinu cave (Corsica), based primarily on purportedly burnt bones. The extremely rich (>1 million fragment) bone accumulation consists primarily of micro-mammals (shrews, lagomorphs, field mice). Despite the authors' valiant – and guarded – argument for human consumption, we feel this is unlikely, based on such a faunal composition. Their dates, ranging from *c.* 19,000 to 6600 cal. BP, are consistent with a mixed assemblage, and were taken on the bones themselves (apart from two on charcoal, dating to the Holocene, when artefacts attest to a human presence). The claimed burning on 5–10 per cent of the bones appears to be manganese staining.

At Corbeddu cave, in Sardinia a human phalanx has been excavated from below a thick layer of endemic deer bones belonging to the species *Megaloceros cazioti* and dated stratigraphically to the LGM (Sondaar *et al*. 1995). The absence of any associated lithics in that or the bone layer above, together with a lack of any anthropogenic modification of the deer bones themselves, leaves it questionable whether any weight should be given to the apparent antiquity of the isolated phalanx and with it any sustained LGM human presence on the island. The purported lithics from an adjacent part of the cave, dated to 17,000–8000 bp (Klein Hofmeijer *et al*. 1989), are not considered particularly convincing as artefacts. Finally, a laminar stone tool industry has been recovered from aeolian

deposits at the site of Santa Maria Is Acquas in southwest Sardinia and dated to 12,000±3000 BP by OSL (Mussi 2007) – the previous estimate of its antiquity, based on geological association, was, seemingly, older: 25,000–18,000 years ago (see Knapp 2013).

The genetic evidence also seems equivocal on the matter of an early presence of modern humans on Sardinia. Pala *et al*. (2009) argued that structure within the mtDNA haplogroup U5b3 is suggestive of people moving to Sardinia *c*. 9000–7000 years ago, a result that would fit with the current Mesolithic archaeological evidence. By comparison, a study of the Y-chromosome haplogroup I-M26 (Contu *et al*. 2008) has suggested an older legacy, with evidence for a founder effect on Sardinia 16,000–25,500 years ago.

Pre-LGM, evidence for the Corsardinia landmass is highly contentious. Approximately 30 water-rolled stone tools were collected along the river banks near Riu Altana (Sardinia); flake based, they have been described as 'ancient Clactonian' (Martini & Ulzega 1992; Palma di Cesnola 1996), but this cannot be verified. Lithics from the open-air site of Sa Pedrosa-Pantallinu (Sardinia), although themselves also originally attributed to an 'Evolved Clactonian' type industry of the Middle Pleistocene (Martini & Ulzega 1992), have been attributed to a period postdating 35,000 years ago, on typological grounds and laminar component (Aureli 2012). Another open-air site, Sa Coa de Sa Multa, was termed a 'lithic extraction site or workshop' and also attributed to the Lower Palaeolithic (Martini & Ulzega 1992; Palma di Cesnola 1996). Apart from a lack of chrono-stratigraphic context, concerns have been raised that these tools are scarcely retouched (Mussi 2002), are rich in cortex and are located on a flint outcrop also used in Neolithic times (Broodbank 2006). Lastly, Coscia Cave (Corsica), which has produced no evidence of stone tools, has a reputed human presence *c*. 60,000 years ago based on possibly allochthonous stone pieces, 'fire structures' and a large concentration (>1000 fragments) of male deer bones and antlers (Bonifay *et al*. 1998). No Middle Palaeolithic contexts, putative or otherwise, have been uncovered on the Sardinian part of the palaeo-island (Palma di Cesnola 1996).

The possibility of an early hominin presence on Corsardinia has been proposed on palaeontological grounds. Sondaar & Van der Geer (2002; 2005) have argued that punctuated faunal turnovers here during the Early Middle Pleistocene and later Middle Pleistocene, *c*. 450,000 BP, were restricted to large herbivores and are difficult to account for without hominin colonization and subsequent predation of these animals. However, the Palaeolithic archaeology linked to both periods (and to the Late Pleistocene) from locales on the island remains controversial. Insularity, cold temperatures (Bigg 1994) and a tightly coastal biodiversity lead us to suspect that Corsardinia would have been less likely to have been visited from the Italian mainland, at least during the Late Pleistocene (post-40,000 years ago), where LGM sites are also scarce (Phoca-Cosmetatou & Spry-Marqués forthcoming).

Maritime activity during the Upper Palaeolithic reaching out to the western side of Corsardinia from the Golfe du Lion–Côte d'Azur area might be plausible, given finds from Cosquer Cave (Calanque de Morgiou near Marseilles, France), a site occupied before, during and after the LGM. Among the images on the decorated walls at Cosquer are several engravings of fish and marine mammals and paintings of the great auk (*Pinguinus impennis*) (Clottes *et al*. 1997; Lambeck & Bard 2000). Bones of the auk have also been recovered from the Palaeolithic levels at Arene Candide, while several other Upper Palaeolithic sites are also known from along this part of the coastal margin and narrow continental shelf (Clottes & Courtin 1996) – all indications of comparatively early maritime activity if not seafaring. The distance across the open sea to reach the northwest coast of Corsardinia, against the counter-clockwise current of Iberian gyre (Fig. 6.4), would still have been of the order of 160–200 km – probably too far. A sea crossing from the North African coast via the Gulf of Tunis marine hotspot may have been closer, but would also have been hampered by prevailing currents parallel to the North African coastline.

Balearic Islands

The current archaeological picture from the most remote island archipelago in the Mediterranean, the Balearics, is that they were not colonized by people until the Mid-Holocene (Palmer *et al*. 1999; Ramis *et al*. 2002) – the latest arrival on any principal island group in the Mediterranean (Broodbank 2013). The closest mainland refugium to these islands is in the coastal uplands south of Valencia (Fig. 6.1). The coastal area north and south of Valencia is bordered by a species-rich broad and shallow continental shelf. Although there has been long-standing interest in fossiliferous Pleistocene vertebrate deposits from the Balearics (Bate 1914), there is no evidence of human activity within them. This is perhaps all the more surprising, given the long presence of human occupation at the site of Cova Cendres on the Valencia coast from the Upper Palaeolithic to the Bronze Age and the clear visibility of the Balearic island of Eivissa (Ibiza) from this coast (Bellard 1995). Our model suggests that earlier occupation should have been possible. So it may yet prove; however, the weight of available evidence currently says otherwise. Interestingly enough, the

source area for colonization of these islands, when it did occur, is thought to have been from the Golfe du Lion region (marine hotspot I), following prevailing winds and sea currents, and not from the much closer (*c*. 70 km) Iberian mainland (Alcover 2008). Although the southerly flow of the Iberian gyre runs between the Spanish coast and the Balearics today (Vergnaud-Grazzini *et al*. 1988), the simulation by Mikolajewicz (2011) suggests that this may not have been the case under glacial conditions (see Fig. 6.4). If his model is accurate, the waters out to the Balearics would have been not only resource-rich, they could also have been easily plied by Pleistocene sea-goers, leaving the late appearance of people here even more puzzling.

Sicily

The earliest securely documented human presence on Sicily is dated to after the LGM, to *c*. 16,700 cal. BP at the site of Grotta dell'Acqua Fitusa (Mussi 2007). Based on both the archaeological and palaeoanthropological characteristics of various Late Epigravettian sites also known from the island – including human remains from Grotta di San Teodoro (*c*. 14,000–10,000 bp) – the late Upper Palaeolithic occupation of Sicily is thought to have spread from mainland South Italy (D'Amore *et al*. 2009; Mannino *et al*. 2011; 2012). The authenticity of the site of Fontana Nuova (Chilardi *et al*. 1996), attributed to the Aurignacian, has been questioned, based on an absence of absolute dates, faunal associations and on typological grounds (Martini *et al*. 2007). The provenance of the human skeletal remains is also doubtful (D'Amore *et al*. 2009). No Middle Palaeolithic sites have been discovered in Sicily, though a number of localities along fluvial terraces in the western part of the island have yielded water-rolled surface finds that have been attributed to a Lower Palaeolithic 'Clactonian'-like industry (Palma di Cesnola 1996). Claims for stone tools of Lower Palaeolithic age have been cast into doubt by Villa (2001) as they occur in regions of the island which would not have been exposed as land at that time.

The Pleistocene vertebrate fossil record from Sicily provides a valuable window into its complex insular history. From an 'oceanic-like island' during the Lower Pleistocene, giving rise to the Monte Pellegrino faunal complex (drawing taxa from a number of sources including via a possible late Miocene land-bridge to North Africa), through varying degrees of isolation to the Late Pleistocene Castello faunal complex, concurrent with the first confirmed appearance of the Epipalaeolithic, Sicily's fauna became increasingly biodiverse and less endemic through time (Marra 2005; 2013).

If the strong currents of the Messina Straits between the island and mainland Italy (Mussi 2007) were almost impassable when open, it seems increasingly likely that the first modern human arrivals entered Sicily via a land-bridge, probably during the LGM. Establishing the existence of such a land-bridge, however, has been fraught with problems. Principal among these has been that this tectonically highly active area has witnessed an uplift of 90 m during the last 100,000 years (Ferranti *et al*. 2006; Lambeck *et al*. 2004). It is only recently that the credibility of such a land-bridge has started to become more firmly established in the literature (Antonioli *et al*. 2012).

A combination of Sicily's geological past, endemic fauna in the Lower and Middle Pleistocene, inundated 'Lower Palaeolithic' locales, no verified Middle Palaeolithic and increasing faunal links to Calabrian Italy all seem to argue against the existence of any significant connection to North Africa during its history (Villa 2001). However, provenance of the type-taxon *Palaeoloxodon falconeri* of Sicily's Middle Pleistocene Spinagallo faunal complex to the African side of the Sicilian-Tunisian isthmus is still entertained as a possibility (Bonfiglio *et al*. 2002). Phylogenetic relationships between a range of non-mammalian fauna (amphibians, reptiles, butterflies, zygaenid moths and dragonflies) also show a degree of affinity across the Strait of Sicily (though less so than across the Straits of Gibraltar), with North Africa providing a reservoir of genetic diversity in these taxa and a source for European re-colonization after the Pleistocene (Husemann *et al*. 2014; Stöck *et al*. 2008).

Both the terrestrial and marine biodiversity hotspots along the North African coast as far as the Gulf of Gabès establish the importance of this maritime margin – confirmed by the presence of hinterland refugia (Husemann *et al*. 2014; Médail & Diadema 2009). Significance is further implied by the pre-LGM antiquity of turtle populations (Clusa *et al*. 2013) along the Libyan coast and potential significance of the Tunisian Shelf as a principal foraging area for *Caretta caretta* (Casale *et al*. 2013). There are, however, no firm indications as yet that humans crossed the Strait of Sicily during the Pleistocene. Lowered sea levels, coupled with a more arid climate and enhanced evaporation, would have increased the velocity of the two-way current through the Strait (Mikolajewicz 2011; Muerdter & Kennet 1983), potentially making any crossing hazardous. On the basis of the model presented here, we hypothesize that the discovery of early human sea-going activities in this part of the central Mediterranean remains plausible, however (see Flemming *et al*. 2003). Islands within these straits, notably Pantalleria, but also now-submerged flat islets (*see* Abbate & Sagri 2012; Shackleton *et al*. 1984, fig. 2) and potentially even Malta and Gozo (often part of Sicily during Pleistocene) may yield

evidence of that activity. The long controversy linked to the 'Neanderthal' molars reported by Keith (1918) from within the Maltese palaeo-fauna sequence at Ghar Dalam cave (Hunt & Schembri 1999) may be worth revisiting (*cf*. Bonanno 2011; Boulinier 2004; Kupczik & Hublin 2010). Further investigation on Sicily itself may also prove fruitful.

Crete

Crete has remained an island separated from the mainland across the last five million years (Lykousis 2009). The first robust evidence for the arrival of people here has, for a long time, been during the Early Neolithic (Broodbank & Strasser 1991). Past claims for Palaeolithic-like tools from the island, and even an anatomically modern human skull in a breccia provisionally dated to *c*. 51,000 years ago, have been dismissed (Strasser *et al*. 2010). Recent finds, however, have placed Crete back at the centre of debates on Pleistocene island occupation.

Over the course of three years, three reports have emerged relating to separate sites, all claiming Middle or even Lower Palaeolithic stone tools. All suffer, though, from the same problem of being surface finds. Twenty-two artefacts collected from secondary deposits on a slope in the area of Loutro (southeast Crete) have been attributed to the late Lower Palaeolithic or early Middle Palaeolithic, based on the tool types – including purportedly a hand-axe, picks and chopping tools (Mortensen 2008). Although Mortensen countered claims that his finds might be geofacts, Strasser *et al*. (2010) continued to voice concern about their authenticity. A fascinating discovery from Gavdos, an islet presently 40 km south of Crete, which has always been separate from its large neighbour, consists of numerous stone tools discovered at open-air localities across the island; a fifth of them are attributed to the Lower Palaeolithic and Mesolithic periods (Kopaka & Matzanas 2009). Predominantly made on local raw materials, including limestone and black flint, these tools are divided into a chronological sequence of five groups based on techno-typological characteristics and patination. In the absence of stratigraphic context or any other more reliable dating method, we await proof of their antiquity.

Possibly the most compelling and most thoroughly studied finds from this latest raft of discoveries consist of more than 400 artefacts made of quartz and quartzite from the Plakias region of southern Crete (Strasser *et al*. 2010; 2011). They have been classified as Palaeolithic, based on techno-typological differences from Mesolithic assemblages identified during the same survey, similarities to known mainland Palaeolithic assemblages and through geological context – namely, an association with marine terraces and palaeosols, providing a date *ante quem* for the material of 107,000 years ago (on the basis of the geological stratigraphy) or 130,000 years (based on palaeosol maturity). The question here is not the authenticity of the tools but their extrapolated age. The excavators acknowledge that the artefacts lay in a secondary deposition and were found on marine terraces of different ages, so caution continues to be required here.

Despite the island being well-apportioned with palaeontological assemblages (Reese 1996), the lack of evidence for any direct association between faunal material and cultural remains – or clear signs of human activity, such as burning, butchery or fragmentation patterns – leaves opinion divided as to the possibility of early occupation on Crete, with many arguing against the possibility (e.g. Hamilakis 1996; Mavridis 2003).

Although well known as a botanical hotspot and refugial location, with many endemic mammal species, Crete is not highlighted as an area of pronounced marine biodiversity or endemism. Our model suggests that the most likely corridor of maritime movement towards Crete would have been through the comparatively rich island waters that lie off the southeast Anatolian coast, bridging terrestrial and marine biodiversity hotspots (Fig. 6.2). Exploitation of these waters, moderately favourable currents on the Levantine gyre (Fig. 6.4) and *c*. 40 km (Rhodes to Karpathos and Kasos to Elasa, Crete) inter-visible stretches (Schüle 1993) between islands (themselves worth considering for early occupation) would make this access route plausible over the last 70,000–190,000 years – the range of time that Strasser *et al*. (2010; 2011) propose. Island hops would be shorter (*c*. 10–25 km for a route from the Peloponnese via Kythira and Antikythira to Crete (Agria Gramvousa). Fish biodiversity around these islands is not published and that of the open sea is otherwise low. The west-central Greece marine biodiversity hotspot is also much further removed to the north, making this perhaps a less likely Pleistocene route to Crete. Lastly, the fact that all of the most recent purported Palaeolithic discoveries lie along and off the southern coast may imply that early occupation of the island was initially one with a maritime orientation. The simulation of LGM sea circulation (Mikolajewicz 2011) predicts that the principal current passing parallel to Crete would have been along its *northern* shore; only during the Holocene, and probably linked to the opening of the straits to the Black Sea, does this current shift, passing along Crete's southern shore (see Vergnaud-Grazzini *et al*. 1988). This could be taken as indirect evidence in support of the antiquity of the new Palaeolithic site

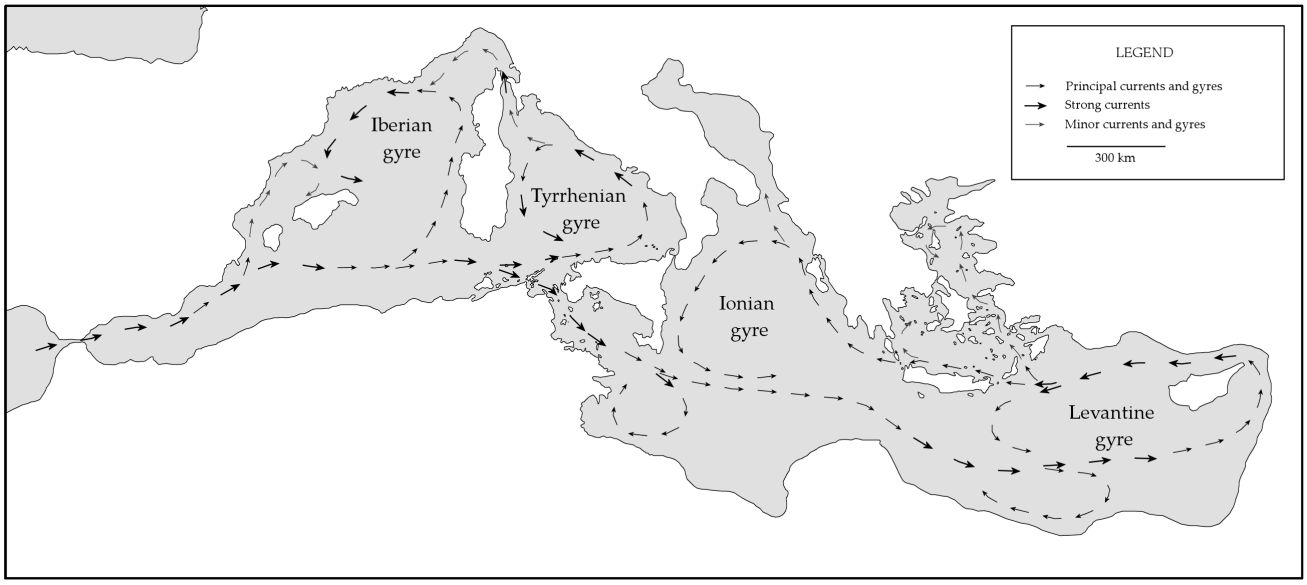

Figure 6.4. *LGM coastal configuration and predicted major currents for the Mediterranean Sea (based on combined information from Mikolajewicz 2011; Shackleton* et al. *1984; Van Andel & Shackleton 1982). (Illustration by R. Rabett.)*

record, assuming a similar current shift during the last interglacial. Equally, it does not wholly remove the possibility that these apparently old sites were part of the Holocene Mesolithic dispersal along these shores that Strasser and colleagues have confidently identified. We wonder if these sites, Palaeolithic and Mesolithic, might signal episodic arrivals along the southern shore during interglacial periods when the current was favourable for landfall here.

Cyprus

Early claims for finds of Upper Palaeolithic appearance have been made on Cyprus, including at Kyrenia and at Tremithos Valley; but both were considered not sufficiently diagnostic and of questionable provenance (Simmons 1999). Simmons (1999) also considers atypical the five lithic artefacts from the Moronou River near Zygi attributed to the Middle Palaeolithic. Adovasio *et al*. (1975) reported the discovery of 62 tools from Ayios Mamas of purported Middle Palaeolithic age; but a lack of illustrations of any of the pieces, their recovery locale – eroding out of gravels – and the presence of Neolithic ground stone tools amongst the finds, leaves the distinct possibility of assemblage mixing, which challenges the likelihood of a Palaeolithic age. Later surveys in the area failed to verify their claims, as neither deposits of clearly Pleistocene antiquity nor any clearly Palaeolithic finds were recovered (Knapp 2013). Common to all these locales has been, again, a lack of stratigraphic or chronological control (Kardulias & Yerkes 2012).

A late Upper Palaeolithic human occupation of Cyprus has now been more firmly established, with at least three sites (Aspros, Nissi and Akrotiri) attributed to the Younger Dryas (*c*. 12,800–11,700 cal. BP) (Ammerman 2010; Simmons 1999; 2011). Using data from these, Ammerman (2010) has argued for a scenario of short, seasonal visits exploiting marine resources. The oldest and most thoroughly dated, Akrotiri, is located on the southern-most peninsula of the island – potentially well served by the smaller current circulating within the interglacial Levantine gyre (Vergnaud-Grazzini *et al*. 1988), but less clearly so under fully glacial conditions. The oldest unproblematic charcoal sample from this site has yielded a date of *c*. 12,692±77cal. BP (ETH-7189) (Simmons 1991; calibration using the Fairbanks 0107 curve). The assemblage, though, was found to contain few microliths, elements that are otherwise ubiquitous from contemporary contexts on the mainland. There continues to be a lively debate about the anthropogenic nature of the two major (and very different) components of the large faunal assemblage from Akrotiri, and the role of humans in the extinction of the island's dwarf hippopotamus and elephant endemics (e.g. Ammerman & Noller 2005; Knapp 2010; Simmons & Mandel 2007; Sondaar & Van der Geer 2002).

Evidence for a human presence on Cyprus significantly older than the Younger Dryas has yet to be demonstrated. Within the parameters of our model, although Cyprus is encompassed within an area of plant biodiversity containing several refugia

on the Anatolian mainland and one in the Troodos Mountains in the southwest of the island, its strongly endemic mammalian fauna carries an extremely low biodiversity (Marra 2005). Cyprus's herpetofauna is more diverse but contains, by comparison, only one endemic species (*Coluber cypriensis*) (Corti *et al*. 1999). Drawing on Coll *et al*. (2010), marine fish biodiversity around the island is lower than in the Levantine coastal waters, with again comparably few endemic species. While at this stage we should not rule anything out, this island is removed by some distance from the nearest marine hotspot (off the southeast Anatolian coast) and lies seemingly outside the sphere of influence that a tied-biome corridor may have afforded during the pre-LGM. On these grounds, occupation during the Younger Dryas may be as early as we can expect from Cyprus.

The Ionian Islands

Central-southern Greece emerges as a key area with a tied-biodiversity zone incorporating a terrestrial hotspot bordered on either side by marine hotspots. Although Palaeolithic finds have been recorded from Corfu, Lefkada and Meganisi (Dousougli 1999; Galanidou 2011; Kourtessi-Philippakis 1999; 2011), all would have been connected to the mainland during periods of lower sea levels. Only the Ionian islands of Cephallonia, Ithaki and Zakynthos, forming a single island during the Pleistocene, were apparently separated from the mainland by *c*. 5–15 km (Ferentinos *et al*. 2012; Shackleton *et al*. 1984; Van Andel & Shackleton 1982; though, see Lykousis 2009).

Notable for its largely continental fauna (Masseti 2012), which includes the Balkan mole (*Talpa stankovici*), an animal unlikely to have arrived by any means other than land-connected migration, isolated examples of palaeoendemic flora and fauna such as the fir *Abies cephalonica* (Politi *et al*. 2009; Scaltsoyiannes *et al*. 1999) and the Balkan wall lizard *Podarcis taurica* (Poulakakis *et al*. 2005) are known from modern Cephallonia. Both support the longer-term insularity hypothesis for this island. A refugial setting is also supported by phylogenetic data for *Caretta caretta*, the island's high rainfall, mountainous and wooded interior and its close association to a glacial refuge area on the adjacent mainland coast.

While putative Middle Palaeolithic tools have been found at open-air sites on Zakynthos (Kourtessi-Philippakis 2011), Cephallonia has been the most extensively explored of the three islands (though this still amounts to a comparatively limited undertaking) and Palaeolithic stone tools have been identified at a number of localities. The most extensive work to date has been that of Kavvadias (1984), centred on the northern cape of Fiskardo, where he recovered a rich surface concentration of stone tools and collected over 200. Subsequent salvage works have uncovered more and a high concentration of lithics is still to be found in the area today, which is increasingly under threat of housing development (Phoca-Cosmetatou & Rabett, pers. observ. 2013). Attributed to the Middle Palaeolithic, these stone tools suffer from the same handicap as so many other assemblages: no stratigraphic context. The paucity of soil present due to surface erosion also makes geological assessment difficult. Other Palaeolithic localities, also predominantly attributed to the Middle Palaeolithic, have been recorded at Mounta and Skala in the southeast of the island in the valley overlooking the town of Sami, in the East (Ankel 1973; Randsborg *et al*. 2002). Cephallonia is still considered the best prospect for Neanderthal island occupation in the Mediterranean (Broodbank 2013) and is the focus of research into this possibility by the current authors (see Phoca-Cosmetatou & Rabett in press).

The Aegean Islands

On the Aegean side of Greece, high fish species endemism and diversity are to be found along the western coastal waters, as far north as the western edge of Thessaly, and including the Northern Sporades island group (principally Skiathos, Skopelos, Alonnisos, Kyra Panagia, Yioura and Skyros). None of the major islands of the northeast Aegean (e.g. Thassos, Limnos, Samothraki or Gökçeada) – our marine biodiversity hotspot VIII – was separated from the continent during the last glacial (Perissoratis & Mitropoulos 1989; Van Andel & Shackleton 1982). This area is connected to neither a terrestrial refugium nor an associated biodiversity hotspot. A claim for Middle Palaeolithic material from Agios Eustratios to the southeast (as yet unpublished) (Laskaris *et al*. 2011) may have been insular and will be of considerable interest when available.

Surface finds from the northern arc of the Sporades have been assigned to the Palaeolithic (Sampson 1996). Systematic work on Alonnisos has yielded mixed Middle Palaeolithic and Mesolithic-like stone tools in secondary deposition; but an excavation of the sedimentary sequence was not able to clarify the provenance of the stone tools (Karkanas 2013; Panagopoulou *et al*. 2001). During periods of lower sea level, many of the Sporades appear to have formed a long, narrow peninsula (Perissoratis & Conispoliatis 2003). Interestingly, though, the high level of species endemism and low frequency of vascular plants on Yioura have been cited as evidence for this island's long-term separation from any other landmass, with the possible exception of Kyra Panagia (Kamari *et al*. 1988). This

leaves the door open for some of the northern Sporades to have harboured early human occupants while the islands were in insular state, a situation echoed by the long-standing claims of Palaeolithic artefacts on Skyros (Cherry 1981; 1990). Together with its own small archipelago of islets, Skyros unquestionably comprised an island setting during the last glacial (Lykousis 2009); then, as now, it was *c*. 40 km off the coast of Euboea. Re-investigation of this island-group and further work on Yioura with the aim of extending the Early Holocene occupation already established at the Cave of the Cyclops (Sampson 2008b) would be encouraged, given the expectations of the model we have presented.

Turning to the south, the lower sea levels of the last glacial meant that the Cyclades archipelago would have formed the heights of a substantial indented isle: the Cyclades Plateau (or 'Cycladia'). None of the surviving peaks of that large island has yielded any evidence of a Palaeolithic presence to date, despite a history of detailed surveys. With so much of the Cyclades Plateau now inundated, at least part of the reason for this may be preservation. The potential for underwater archaeology to recover fragments of an early occupation has been broached (Kapsimalis *et al*. 2009). The recovery of stone tools from Melos, one of the many smaller islands lying off the then Cycladian shoreline, but which has lost far less of its Pleistocene surface area as a result of sea-level rise, is a case in point for the preservation argument.

Chelidonio (2001) reported the recovery of 126 stone tools from Melos. All but one were surface finds made on beach pebbles of vitreous rhyolite. The exception is made on obsidian. (The earliest evidence of Melian obsidian, one of the primary sources for this volcanic stone in the Mediterranean, otherwise comes from *c*. 12,000 cal. BP levels at Franchthi, implying transportation from the island: Runnels 1995). Among the finds, Chelidonio reported choppers and chopping tools, flakes, scrapers and cores, all of which he characterized as expedient tools. The use of centripetal and discoid knapping techniques led him to assign a Middle Palaeolithic identity and date to this assemblage. Although his claim was met with some scepticism and the possibility of their being Mesolithic artefacts has been raised (in Chelidonio 2001), we find little in the local record of the Mesolithic to support this and are inclined to agree with other commentators (Broodbank 2006; 2013; Harvati *et al*. 2009; Knapp 2013) in seeing these finds as credibly Palaeolithic. A comparison of the Melian finds to other Mesolithic Aegean assemblages (e.g. Maroulas, Kythnos; Cave of Cyclops, Yioura; Kerame, Ikaria) highlights the differences between them. All three Mesolithic assemblages have a strong component of obsidian tools (although stratigraphic provenance at Yioura is questionable; Sampson *et al*. 2012), with principal lithic raw materials otherwise being local flint and quartz; microliths are present whereas the big core tools that Chelidonio reported are not, though at Kerame 3 cores made on rhyolite are reported (Sampson 2008a,b; Sampson *et al*. 2012). Fish biodiversity and rates of endemism appear at somewhat reduced rates in the vicinity of the Cyclades compared with the coastal waters of mainland Greece; nonetheless this area gives every indication of being part of a marine biodiversity hotspot: in which case, the lowered sea levels and wide exposure of the shallow Cyclades Plateau – perhaps especially on its more protected western shores – could have re-situated those productive waters into its bays and among its neighbouring islands.

Conclusion: towards a Pleistocene Island Archaeology

Over the last 40 years, there have been major shifts in approaches to islands and Island Archaeology, with researchers increasingly realizing the complex interplay between land and sea, environment and culture, seafaring and colonization (Phoca-Cosmetatou 2011a). Lively debate in response to themes in island biogeography has taken place on notions of isolation and interaction, on the role of physical and social boundaries and on island identity (e.g. Broodbank 2000; Eriksen 1993; Erlandson 2008; Horden & Purcell 2000; Knapp 2008; Rainbird 2007; Robb 2001). These concerns are primarily relevant in the context of establishing and maintaining permanent island settlements and the way in which these create and transform island societies – a process that in the Mediterranean occurred during the Neolithic (Broodbank 2013; Dawson 2011; Phoca-Cosmetatou 2011a).

The exploration of a pre-Neolithic human presence on Mediterranean islands has only recently begun to emerge as a field of enquiry, and has arisen through a conscious shift in research priorities and modified theoretical approach away from island colonization (e.g. Cherry 1990) to themes such as 'maritime activity' (Broodbank 2006) and the origins of seafaring (Anderson *et al*. 2010). Notions of island identity, insularity and full-scale colonization are recognized as less appropriate themes for earlier periods. The large-scale multi-period surveys, typical for studying later prehistoric and classical periods, are also less well aligned to the geography and distribution of earlier evidence. This fact, we have argued here, has at least partly shaped the scale and nature of recovery of an island Palaeolithic. With Palaeolithic

archaeologists now taking the lead for the first time, the focus of investigation has become the initial visitation and exploration of islands for reasons including the utilization of island resources. Interdisciplinary projects employing ecologically and geologically informed models have tailored survey and reconnaissance to the specific parameters of earlier occupation (Ammerman 2010; Broodbank 2006; 2013; Knapp 2013; Strasser *et al*. 2010; 2011). This has proven especially productive for locating a substantial Mesolithic island prehistory, which few anticipated existed in the Mediterranean (Ammerman 2010; Depalmas 2013; Panagopoulou *et al*. 2001; Sampson 2008a,b; Sampson *et al*. 2012; Strasser *et al*. 2010). New Palaeolithic finds that have been made alongside this search have become headline grabbers, but concrete evidence of island use still only extends back to *c*. 16,000 years ago and mostly later, possibly associated with the climatic downturn of the Younger Dryas. Most of the Palaeolithic evidence remains, as it always has done, hampered by find locales being in areas of secondary deposition, by assemblages comprising only surface scatters, and over-reliance on typologically-driven relative chronologies. Absolute dates continue to elude. Unarguably, the reorientation in method and approach has produced some of the most compelling Palaeolithic evidence to date and encourages us not to be overwhelmed by the substantial preservation issues that affect the integrity of the earliest records. We are left to wonder if the antiquity of the first strong evidence of island use more accurately reflects the timing when conditions and shorelines last stabilized than it does the first appearance of people on islands. Irrespective of this, fragmentary evidence hinting at a much older history has appeared whichever recovery criteria have been used by previous island investigators. This is certainly encouraging. We have argued, though, that there has still been little systematic effort to conceptualize and design a specifically Palaeolithic approach with which to interrogate the island record. In this paper we have taken, we hope, some first steps towards addressing that.

The logic we have followed is simple. There is good evidence that Palaeolithic groups, including Neanderthals, favoured the stable resources and equitable conditions of terrestrial refugia. Ecological studies have demonstrated a link between the distribution of biodiversity hotspots and the occurrence of these refugia. With our interest directed towards the accessibility and use of island contexts, we have sought first to extrapolate this relationship to marine settings, marking the locations of marine biodiversity hotspots using the same criteria (endemism, biodiversity and threat). We have hypothesized that within the vicinity of these marine hotspots there should be marine refugia – areas of long-term stability. The existence of such places within the Mediterranean is supported by proxy through phylogeographic studies and through tertiary observations showing a correspondence in distribution patterns of marine animals, which exploit both land and sea environments, to biodiversity hotspots. Our contention is that those areas where there is overlap between marine and terrestrial hotspots (and hence implied refugia), and where there are islands that have been separated from the mainland during the Upper Pleistocene, will provide the best candidates on which to find compelling evidence of Palaeolithic island use.

In the western Mediterranean there are two areas that exhibit an immediate association between marine and terrestrial biodiversity hotspots. The Balearics remain an enigma. All of the conditions examined here are right for the early appearance of humans in this archipelago and yet the current state of evidence places this as the last major island group to be inhabited in the Mediterranean. Possibly the heavily unbalanced nature of the fauna here simply meant that these islands were never attractive to early visitation. The straits between Tunisia and Sicily may have confronted early human groups with a substantial obstacle. Island-hopping, though, would have been possible, and further investigation of islands within this area (including Sicily) would surely be a valuable exercise. Despite their individual or combined size, we suspect that the pre-LGM Upper Pleistocene occupation evidence on Corsica and Sardinia may remain controversial in the absence of any marine biodiversity hotspot linking this landmass to any adjacent mainland. It definitely does not preclude the possibility of an Early or Middle Pleistocene hominin presence, as both the record of faunal turnovers and the lithic record may attest; however, close attention needs to be paid to the earlier history of continental links to the Italian mainland if we are to propose even more ancient movements to these islands by sea.

Turning east, we have raised queries about the likelihood of occupation on Cyprus being older than the Epipalaeolithic which has already been discovered, because of its isolation from the kind of corridor of movement that a marine hotspot would have afforded. Based on our model, Crete may offer greater likelihood of early occupation owing to its association with the tied-biome between terrestrial southwestern Anatolia and the southeast Aegean (VII). The discovery of all the new purported Palaeolithic sites on the southern coast may be linked to changes in the prevailing off-shore current between the north (under glacial conditions) and south (under interglacial ones) of the island, leading us to specu-

late that sea-going movements in the Pleistocene and Early Holocene may have been strongly affected by prevailing currents. Of all the Ionian Islands, the Cephallonia–Ithaki–Zakynthos landmass continues to be considered the most likely place in the Mediterranean to find substantial evidence for Neanderthal island presence, and has some of the most persistent evidence of Middle Palaeolithic artefacts. Marine and terrestrial biodiversity hotspots overlap on the western margin of central Greece, implying long-term resource stability. A similarly tied-biome along the eastern margin of central Greece lends credibility to the Middle Palaeolithic assemblages from Melos and highlights possibilities for neighbouring islands that were not part of the Cycladian Plateau. It also justifies returning to the Palaeolithic artefacts from Skyros and possibly other Sporades islands.

While, undoubtedly, there is a need to refine the geographic resolution of apparent areas of overlap between marine and terrestrial data defined in the model that we have presented here, our primary goal has been to draw attention to the existence of such a link. A much more systematic treatment of these data is clearly required before any definitive conclusions can be drawn. For example, one valuable addition would be to create a detailed picture of the locality of Pleistocene continental shelves in order to obtain a more accurate sense of where fish species richness was likely greatest. Tying marine and terrestrial biomes gives reason for optimism that such research into Pleistocene island occupation will be rewarded.

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